Econ 311: Behavioral and Experimental Economics

Prof. Jeffrey Naecker

Wesleyan University

Introduction to Time Preferences

Motivation

- Which would you rather have?
  - \$100 today OR \$95 one month

Motivation

- Which would you rather have?
  - $100 today OR $95 one month
  - $100 today OR $97 one month

Motivation

- Which would you rather have?
  - \$100 today OR \$95 one month
  - \$100 today OR \$97 one month
  - \$100 today OR \$99 one month

Motivation

- Which would you rather have?
  - \$100 today OR \$95 one month
  - \$100 today OR \$97 one month
  - \$100 today OR \$99 one month
  - \$100 today OR \$101 one month

Motivation

- Which would you rather have?
  - \$100 today OR \$95 one month
  - \$100 today OR \$97 one month
  - \$100 today OR \$99 one month
  - \$100 today OR \$101 one month
  - \$100 today OR \$103 one month

Motivation

- Which would you rather have?
    - \$100 today OR \$95 one month
    - \$100 today OR \$97 one month
    - \$100 today OR \$99 one month
    - \$100 today OR \$101 one month
    - \$100 today OR \$103 one month
    - \$100 today OR \$105 one month

Motivation

- Which would you rather have?
  - \$100 today OR \$95 one month
  - \$100 today OR \$97 one month
  - \$100 today OR \$99 one month
  - \$100 today OR \$101 one month
  - \$100 today OR \$103 one month
  - \$100 today OR \$105 one month
- If you value money today more than the same amount of money in the future, then we say you are *impatient*

Consumption Over Time

- Stream of consumption (or wealth or income) over T time periods, starting with period 1:

$$c = (c_1, c_2, c_3, \ldots, c_T)$$

  - Example: $T = 3$ periods: $(c_1, c_2, c_3) = (\$5, \$10, \$0)$

Consumption Over Time

- Stream of consumption (or wealth or income) over T time periods, starting with period 1:

$$c = (c_1, c_2, c_3, \ldots, c_T)$$

  - Example: $T = 3$ periods: $(c_1, c_2, c_3) = (\$5, \$10, \$0)$
- Utility is function of the entire stream of income:

$$U(c) = f(c_1, c_2, c_3, \ldots, c_T)$$

Consumption Over Time

- Stream of consumption (or wealth or income) over T time periods, starting with period 1:

$$c = (c_1, c_2, c_3, \ldots, c_T)$$

  - Example: $T = 3$ periods: $(c_1, c_2, c_3) = (\$5, \$10, \$0)$
- Utility is function of the entire stream of income:

$$U(c) = f(c_1, c_2, c_3, \ldots, c_T)$$

- If *impatient*, then would prefer to have an extra dollar today rather than tomorrow, implying

$$\frac{\partial U}{\partial c_t} > \frac{\partial U}{\partial c_{t+1}}$$

  or equivalently:

$$\frac{\frac{\partial U}{\partial c_{t+1}}}{\frac{\partial U}{\partial c_t}} < 1$$

Time Consistency

- Suppose decision maker (DM) is making plan for consumption in future (possibly uncertain) states
- In the standard model, they make a complete contingent plan and stick to it
  - That is, they are happy to commit to their plan at any earlier date
  - When they arrive at the future state, they will not want to change their plan
  - They are *time consistent*

Time Consistency

- Suppose decision maker (DM) is making plan for consumption in future (possibly uncertain) states
- In the standard model, they make a complete contingent plan and stick to it
  - That is, they are happy to commit to their plan at any earlier date
  - When they arrive at the future state, they will not want to change their plan
  - They are *time consistent*
- A formal definition
  - Let consumption for period τ chosen at period $t \leq \tau$ be $c(\tau|t)$
  - DM is time consistent if $c(\tau|t) = c(\tau|\tau)$ for any $t \leq \tau$

The General Discounting Model

- Consider a stream of consumption over time, starting with period t: $c_t^T = (c_t, c_{t+1}, c_{t+2}, \ldots, c_T)$
- Discounted utility model says that the utility at period t of the whole stream is

$$
\begin{aligned}
U_t(c_t^T) &= D(0)u(c_t) + D(1)u(c_{t+1}) + D(2)u(c_{t+2}) + \ldots + D(T-t)u(\\
&= \sum_{\tau=t}^{T} D(\tau - t)u(c_\tau)
\end{aligned}
$$

The General Discounting Model

- Consider a stream of consumption over time, starting with period t: $c_t^T = (c_t, c_{t+1}, c_{t+2}, \ldots, c_T)$
- Discounted utility model says that the utility at period t of the whole stream is

$$U_t(c_t^T) = D(0)u(c_t) + D(1)u(c_{t+1}) + D(2)u(c_{t+2}) + \ldots + D(T-t)u(c$$

$$= \sum_{\tau=t}^{T} D(\tau - t)u(c_\tau)$$

- Impatience implies that $D(t+1) \leq D(t)$, ie D is decreasing
  - Same amount of consumption has smaller impact on utility if it is farther in the future
- Typically set $D(0) = 1$

MRS Between Periods

- Consider two periods $t + k$ and $t + k + 1$
- What is MRS of consumption between these two periods?
  - $\frac{dU_t}{dc_{t+k}} = D(k)u'(c_{t+k})$
  - $\frac{dU_t}{dc_{t+k+1}} = D(k+1)u'(c_{t+k+1})$
  - $MRS = \frac{D(k+1)u'(c_{t+k+1})}{D(k)u'(c_{t+k})}$
- If we assume price of consumption is the same in all periods, then we have
  - $MRS = 1 \implies \frac{D(k+1)}{D(k)} = \frac{u'(c_{t+k})}{u'(c_{t+k+1})}$

Time Consistency and Discounting

- Suppose DM is in period t, making decision about consumption in period r and $r+1$ in the future
  - Tradeoff will be governed by $\frac{D(r-t)}{D(r+1-t)} = \frac{u'(c_r)}{u'(c_{r+1})}$

Time Consistency and Discounting

- Suppose DM is in period t, making decision about consumption in period r and $r+1$ in the future
  - Tradeoff will be governed by $\frac{D(r-t)}{D(r+1-t)} = \frac{u'(c_r)}{u'(c_{r+1})}$
- Suppose DM is in period $s > t$, making decision about consumption in period r and $r+1$ (still in the future)
  - Tradeoff will be governed by $\frac{D(r-s)}{D(r+1-s)} = \frac{u'(c_r)}{u'(c_{r+1})}$

Time Consistency and Discounting

- Suppose DM is in period t, making decision about consumption in period r and $r+1$ in the future
  - Tradeoff will be governed by $\frac{D(r-t)}{D(r+1-t)} = \frac{u'(c_r)}{u'(c_{r+1})}$
- Suppose DM is in period $s > t$, making decision about consumption in period r and $r+1$ (still in the future)
  - Tradeoff will be governed by $\frac{D(r-s)}{D(r+1-s)} = \frac{u'(c_r)}{u'(c_{r+1})}$
- Time consistency says optimal c_r and c_{r+1} should not depend on whether consumption decision is made in period s or t
- Therefore $\frac{D(r-s)}{D(r+1-s)} = \frac{D(r-t)}{D(r+1-t)}$ for any r, s, t

Time Consistency and Discounting

- Suppose DM is in period t, making decision about consumption in period r and $r+1$ in the future
  - Tradeoff will be governed by $\frac{D(r-t)}{D(r+1-t)} = \frac{u'(c_r)}{u'(c_{r+1})}$
- Suppose DM is in period $s > t$, making decision about consumption in period r and $r+1$ (still in the future)
  - Tradeoff will be governed by $\frac{D(r-s)}{D(r+1-s)} = \frac{u'(c_r)}{u'(c_{r+1})}$
- Time consistency says optimal c_r and c_{r+1} should not depend on whether consumption decision is made in period s or t
- Therefore $\frac{D(r-s)}{D(r+1-s)} = \frac{D(r-t)}{D(r+1-t)}$ for any r, s, t
- For time consistency, any discount factors separated by same amount of periods should have the same ratio

Discounted Expected Utility

- In particular, if periods are consecutive, we must have for any k

$$\frac{D(k+1)}{D(k)} = \frac{D(1)}{D(0)} = \delta$$

- δ is the *discount factor*

Discounted Expected Utility

- In particular, if periods are consecutive, we must have for any k

$$\frac{D(k+1)}{D(k)} = \frac{D(1)}{D(0)} = \delta$$

- δ is the *discount factor*
- Then $D(k) = \delta^k$, where $0 \leq \delta \leq 1$
- Thus time-consistency implies that we can write utility as

$$\begin{aligned} U_t(c_t^T) &= u(c_t) + \delta u(c_{t+1}) + \delta^2 u(c_{t+2}) + \ldots + \delta^{T-t} u(c_T) \\ &= \sum_{\tau=t}^{T} \delta^{(t-\tau)} u(c_\tau) \end{aligned}$$

- This is *geometric* or *exponential* discounting
- Agent becomes more impatient as $\delta \to 0$

Example: Doing Your Laundry

- Suppose your utility each day is proportional to how many clean outfits you have to wear
- On Friday that you have just 2 clean outfits left
- You can do laundry on Friday, Saturday, or Sunday, or Monday
- Doing laundry is annoying: -5 utils the day you choose to do it
- Doing laundry gets you 5 clean outfits, but you use one each day
- In summary:

	Utility on day			
	F	Sa	Su	M
Do laundry Fri	-3	5	4	3
Do laundry Sat	2	-4	5	4
Do laundry Sun	2	1	-5	5
Do laundry Mon	2	1	0	-5

When Do You Do Your Laundry?

- From Friday's perspective, what is overall utility of doing laundry on

When Do You Do Your Laundry?

- From Friday's perspective, what is overall utility of doing laundry on

Friday?	-3	$+\delta(5)$	$+\delta^2(4)$	$+\delta^3(3)$
Saturday?	2	$+\delta(-4)$	$+\delta^2(5)$	$+\delta^3(4)$
Sunday?	2	$+\delta(1)$	$+\delta^2(-5)$	$+\delta^3(5)$
Monday?	2	$+\delta(1)$	$+\delta^2(0)$	$+\delta^3(-5)$

When Do You Do Your Laundry?

- From Friday's perspective, what is overall utility of doing laundry on

$$\begin{array}{rrrrr} \text{Friday?} & -3 & +\delta(5) & +\delta^2(4) & +\delta^3(3) \\ \text{Saturday?} & 2 & +\delta(-4) & +\delta^2(5) & +\delta^3(4) \\ \text{Sunday?} & 2 & +\delta(1) & +\delta^2(-5) & +\delta^3(5) \\ \text{Monday?} & 2 & +\delta(1) & +\delta^2(0) & +\delta^3(-5) \end{array}$$

- Utilities under various values of δ:

	Total utility if $\delta =$			
	1	0.6	0.52	0.25
Do laundry Fri	9*	2.09	1.10	-1.45
Do laundry Sat	7	2.27*	1.83	1.38
Do laundry Sun	3	1.88	1.87*	2.02
Do laundry Mon	-2	1.52	1.82	2.17*

Checking Follow Through

- Suppose your $\delta = 0.6$, so on Friday you decide to do laundry on Saturday
- Saturday morning comes, and you re-evaluate your choices
- Note that "today", ie period 1, is now Saturday
- From Saturday's perspective, what is utility of doing laundry on

Checking Follow Through

- Suppose your $\delta = 0.6$, so on Friday you decide to do laundry on Saturday
- Saturday morning comes, and you re-evaluate your choices
- Note that "today", ie period 1, is now Saturday
- From Saturday's perspective, what is utility of doing laundry on

$$\begin{array}{rrrrl} \text{Saturday?} & -4 & +(0.6)(5) & +(0.6)^2(4) & = 0.44 \\ \text{Sunday?} & 1 & +(0.6)(-5) & +(0.6)^2(5) & = -0.20 \\ \text{Monday?} & 1 & +(0.6)(0) & +(0.6)^2(-5) & = -0.80 \end{array}$$

Checking Follow Through

- Suppose your $\delta = 0.6$, so on Friday you decide to do laundry on Saturday
- Saturday morning comes, and you re-evaluate your choices
- Note that "today", ie period 1, is now Saturday
- From Saturday's perspective, what is utility of doing laundry on

$$\begin{array}{rrrrl} \text{Saturday?} & -4 & +(0.6)(5) & +(0.6)^2(4) & = \;\; 0.44 \\ \text{Sunday?} & 1 & +(0.6)(-5) & +(0.6)^2(5) & = -0.20 \\ \text{Monday?} & 1 & +(0.6)(0) & +(0.6)^2(-5) & = -0.80 \end{array}$$

- Will you follow through with plan?

Checking Follow Through

- Suppose your $\delta = 0.6$, so on Friday you decide to do laundry on Saturday
- Saturday morning comes, and you re-evaluate your choices
- Note that "today", ie period 1, is now Saturday
- From Saturday's perspective, what is utility of doing laundry on

$$\begin{array}{rrrrr} \text{Saturday?} & -4 & +(0.6)(5) & +(0.6)^2(4) & = 0.44 \\ \text{Sunday?} & 1 & +(0.6)(-5) & +(0.6)^2(5) & = -0.20 \\ \text{Monday?} & 1 & +(0.6)(0) & +(0.6)^2(-5) & = -0.80 \end{array}$$

- Will you follow through with plan? Yes, since utility of doing on Saturday is still highest

How Do We Measure Time Preferences?

- Suppose you are indifferent between \$100 today and \$X in one month
- Utility of \$100 today: $u(\$100)$
- Utility of \$X next month: $\delta u(\$X)$ (assuming monthly discount factor)
- Thus we must have $u(\$100) = \delta u(\$X)$, which implies

$$\delta = \frac{u(\$100)}{u(\$X)}$$

- If we make the assumption that $u(x) = x$, then

$$\delta = \frac{100}{X}$$

- Thus we can estimate time preferences by looking at switch point on price list

Lab Evidence: McClure et at (2007)

- Subjects told to come into the lab thirsty
- Experiment lasts at least 30 minutes
- Treatment 1 (immediate): choose either
  - 1 juice now (early) OR
  - 2 juices in 5 minutes (later)

Lab Evidence: McClure et at (2007)

- Subjects told to come into the lab thirsty
- Experiment lasts at least 30 minutes
- Treatment 1 (immediate): choose either
  - 1 juice now (early) OR
  - 2 juices in 5 minutes (later)
- Treatment 2 (delay): choose either
  - 1 juice in 20 minutes (early) OR
  - 2 juices in 25 minutes (later)
- Subjects know this is their only chance to get a drink during the experiment

Results

- What behavior do we expect from discounted exponential utility model?

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments
- What actually happened?

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments
- What actually happened?
  - Treatment 1 (immediate):

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments
- What actually happened?
  - Treatment 1 (immediate): 60% choose early option

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments
- What actually happened?
  - Treatment 1 (immediate): 60% choose early option
  - Treatment 2 (delay):

Results

- What behavior do we expect from discounted exponential utility model?
  - Break experiment up into five-minute periods
  - Treatment 1: choose early option if $u(1) > \delta u(2)$
  - Treatment 2: choose early option if $\delta^4 u(1) > \delta^5 u(2)$
    - Reduces to $u(1) > \delta u(2)$, same as Treatment 1
  - Thus we expect same percentage subjects choosing early option in both treatments
- What actually happened?
  - Treatment 1 (immediate): 60% choose early option
  - Treatment 2 (delay): 30% choose early option

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes “high brow” and “low brow” movies
  - “High brow” movies: Schindler’s List, Like Water for Chocolate
  - “Low brow” movies: The Mask, Mrs. Doubtfire

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes "high brow" and "low brow" movies
  - "High brow" movies: Schindler's List, Like Water for Chocolate
  - "Low brow" movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes “high brow” and “low brow” movies
  - “High brow” movies: Schindler’s List, Like Water for Chocolate
  - “Low brow” movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes "high brow" and "low brow" movies
  - "High brow" movies: Schindler's List, Like Water for Chocolate
  - "Low brow" movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?
  - As in previous experiment, expect same percentage choosing low brow movie in two treatments
- Results:

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes “high brow” and “low brow” movies
  - “High brow” movies: Schindler’s List, Like Water for Chocolate
  - “Low brow” movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?
  - As in previous experiment, expect same percentage choosing low brow movie in two treatments
- Results:
  - Treatment 1 (immediate):

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes "high brow" and "low brow" movies
  - "High brow" movies: Schindler's List, Like Water for Chocolate
  - "Low brow" movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?
  - As in previous experiment, expect same percentage choosing low brow movie in two treatments
- Results:
  - Treatment 1 (immediate): 66% low brow

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes "high brow" and "low brow" movies
  - "High brow" movies: Schindler's List, Like Water for Chocolate
  - "Low brow" movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?
  - As in previous experiment, expect same percentage choosing low brow movie in two treatments
- Results:
  - Treatment 1 (immediate): 66% low brow
  - Treatment 2 (delay):

Field Evidence: Read, Loewenstein, and Kalyanaraman (1999)

- Subjects get vouchers from certain movies off of a list
- List includes "high brow" and "low brow" movies
  - "High brow" movies: Schindler's List, Like Water for Chocolate
  - "Low brow" movies: The Mask, Mrs. Doubtfire
- Treatment 1 (immediate): Subjects pick movie for tonight
- Treatment 2 (delay): Subjects pick movie for one week from now
- Expect results from discounted exponential model?
  - As in previous experiment, expect same percentage choosing low brow movie in two treatments
- Results:
  - Treatment 1 (immediate): 66% low brow
  - Treatment 2 (delay): 37% low brow

Time Inconsistency

- In actuality, we observe much behavior that is *time inconsistent*
  - That is, consumers make a different choice for tomorrow's consumption when asked today vs when asked tomorrow
  - Such consumers will have a *self-control problem*

Time Inconsistency

- In actuality, we observe much behavior that is *time inconsistent*
  - That is, consumers make a different choice for tomorrow's consumption when asked today vs when asked tomorrow
  - Such consumers will have a *self-control problem*
- Also, we see that some people are aware of their time inconsistency
  - A *naive* agent believes (incorrectly) that he will follow through on his plans
  - A *sophisticated* agent knows that she may not follow through, so she may look for ways to *commit* herself to the plan

Quasi-hyperbolic Discounting

- First proposed by Strotz (1955) and popularized by Laibson (1997)
- Specifies discount factor for $k > 0$ as

$$D(k) = \beta\delta^k$$

  where $0 \leq \beta \leq 1$
- Note $D(0) = 1$ still (and this is important!)

Quasi-hyperbolic Discounting

- First proposed by Strotz (1955) and popularized by Laibson (1997)
- Specifies discount factor for $k > 0$ as

$$D(k) = \beta\delta^k$$

  where $0 \leq \beta \leq 1$
- Note $D(0) = 1$ still (and this is important!)
- Plugging in to utility function:

$$U_t = u(c_t) + \beta\left[\delta u(c_{t+1}) + \delta^2 u(c_{t+2}) + \delta^3 u(c_{t+3}) + \ldots\right]$$

- Also known as β-δ *discounting* or *present-bias*

Comparing Geometric and Quasi-hyperbolic Discounting

Ratio	Geometric	Hyberbolic
$\frac{D(1)}{D(0)}$	δ	$\beta\delta$
$\frac{D(k+1)}{D(k)}$ for $k > 0$	δ	δ

- Any case were $\frac{D(k+1)}{D(k)}$ depends on k will in general lead to time inconsistent behavior
- It is the β in the β-δ model that is making behavior time-inconsistent

Example: How QHD Leads to Time-Inconsistency

- Three periods: $t = 0, 1, 2$
- Two options:
  1. Eat well: $u_1 = 5$, $u_2 = 10$
  2. Eat poorly: $u_1 = 8$, $u_2 = 6$
- Assume that DM has QHD preferences with $\beta = \frac{1}{2}$, $\delta = 1$

Example: How QHD Leads to Time-Inconsistency

- Three periods: $t = 0, 1, 2$
- Two options:
  1. Eat well: $u_1 = 5$, $u_2 = 10$
  2. Eat poorly: $u_1 = 8$, $u_2 = 6$
- Assume that DM has QHD preferences with $\beta = \frac{1}{2}$, $\delta = 1$
- Decision in period 0:

Example: How QHD Leads to Time-Inconsistency

- Three periods: $t = 0, 1, 2$
- Two options:
  1. Eat well: $u_1 = 5$, $u_2 = 10$
  2. Eat poorly: $u_1 = 8$, $u_2 = 6$
- Assume that DM has QHD preferences with $\beta = \frac{1}{2}$, $\delta = 1$
- Decision in period 0:
  - Eat well: $U = \frac{1}{2}5 + \frac{1}{2}10 = 7.5$
  - Eat poorly: $U = \frac{1}{2}8 + \frac{1}{2}6 = 7$
  - Decision: eat well

Example: How QHD Leads to Time-Inconsistency

- Three periods: $t = 0, 1, 2$
- Two options:
  1. Eat well: $u_1 = 5$, $u_2 = 10$
  2. Eat poorly: $u_1 = 8$, $u_2 = 6$
- Assume that DM has QHD preferences with $\beta = \frac{1}{2}$, $\delta = 1$
- Decision in period 0:
  - Eat well: $U = \frac{1}{2}5 + \frac{1}{2}10 = 7.5$
  - Eat poorly: $U = \frac{1}{2}8 + \frac{1}{2}6 = 7$
  - Decision: eat well
- Decision in period 1:

Example: How QHD Leads to Time-Inconsistency

- Three periods: $t = 0, 1, 2$
- Two options:
  1. Eat well: $u_1 = 5$, $u_2 = 10$
  2. Eat poorly: $u_1 = 8$, $u_2 = 6$
- Assume that DM has QHD preferences with $\beta = \frac{1}{2}$, $\delta = 1$
- Decision in period 0:
  - Eat well: $U = \frac{1}{2}5 + \frac{1}{2}10 = 7.5$
  - Eat poorly: $U = \frac{1}{2}8 + \frac{1}{2}6 = 7$
  - Decision: eat well
- Decision in period 1:
  - Eat well: $U = 5 + \frac{1}{2}10 = 10$
  - Eat poorly: $U = 8 + \frac{1}{1}6 = 11$
  - Decision: eat poorly